Non-Linear Position Reconstruction

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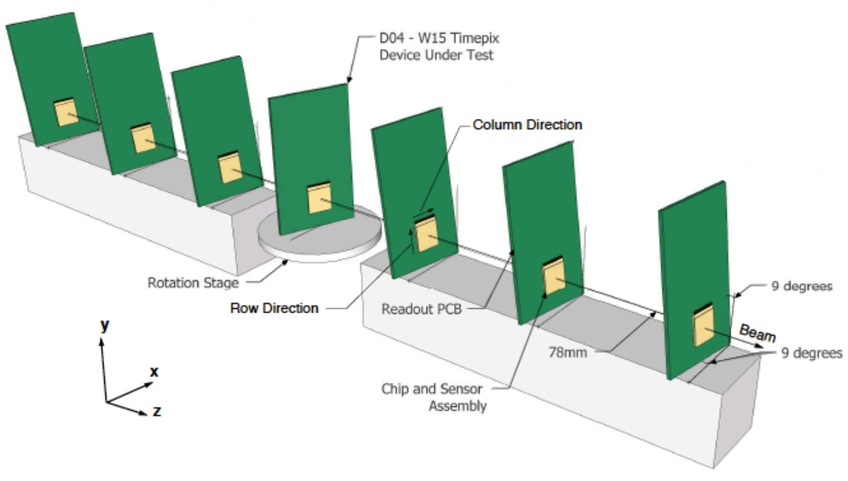
Test Beam Telescope

The Vertex Locator, VELO, is a tracking detector for the proton proton interaction point at the LHCb experiment. The VELO is the closest detector to the beam so it has received the most radiation out of all the detectors at the LHC. There are new pixel sensors that are currently being tested to replace the damaged sensors. [1]
This is done while at a test beam, the sensors are placed into a telescope.



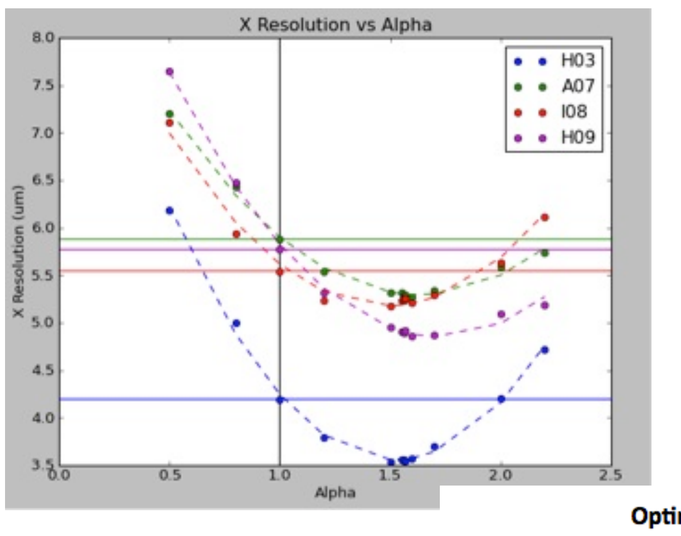
The following analysis was done with older test beam data. It will be applied to the new data we receive later this year.

Non - Linear Centre of Gravity

A linear centre of gravity algorithm is a weighted average of hit positions. It uses the positions of the hits and the charges associated with each hit. [2] The non-linearity of the charge sharing suggests that maybe a non-linear algorithm might provide better results.

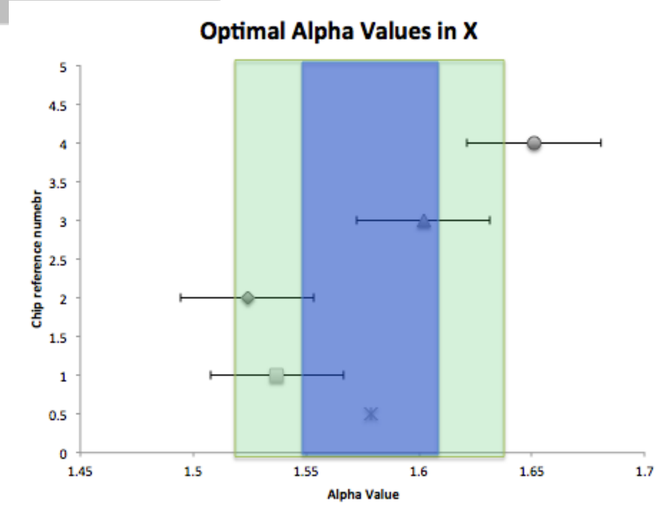
The non-linear centre of gravity addresses the non-linear charge sharing by raising each signal to an exponent.

$$x_{cluster} = \frac{\sum x_i S_{ii}^{\alpha}}{\sum S_{ii}^{\alpha}}$$



This is a scan over different exponent values with chosen pixel chips. The average value of alpha was used through the rest of the study.

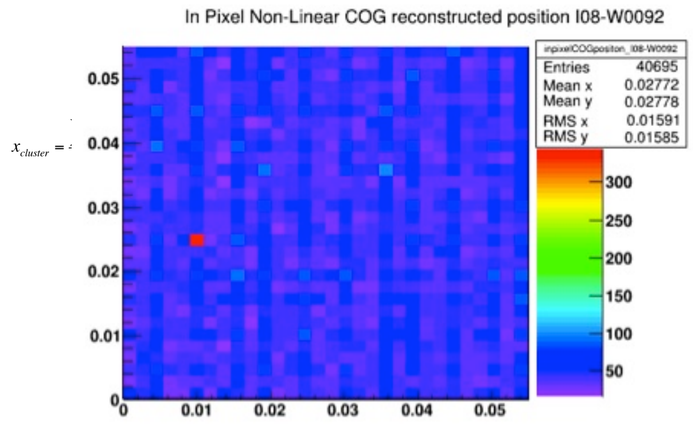
This was justified by the following graph.
The blue rectangle is one sigma while the green is two sigma from the mean.



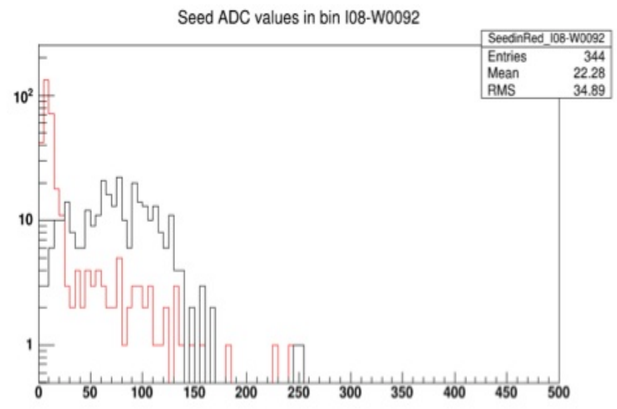
Results

Chip	Residual in x(µm) Non-linear COG	Residual in x(µm) Linear COG	Difference(µm)
G08-W0087	3.75 ± 0.0338	4.79 ± 0.0364	1.04
I06-W0092	4.51 ± 0.0367	5.07 ± 0.0394	0.56
H03-W0092	3.77 ± 0.0328	4.49 ± 0.0372	0.72
A07-W0087	5.50 ± 0.0395	6.14 ± 0.0402	0.64
I08-W0092	5.24 ± 0.0445	5.86 ± 0.0493	0.62
H09-W0082	4.71 ± 0.0433	5.82 ± 0.0490	1.11
I09-W0092	4.51 ± 0.0448	6.42 ± 0.0496	1.91
I08-W0087	4.34 ± 0.0454	5.77 ± 0.0463	1.43

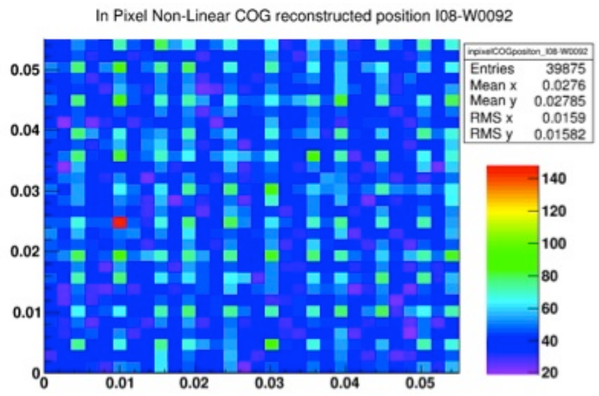
As the beam is homogenous the distribution should also be homogenous and symmetric. After a closer inspection of the reconstructed data there seems to be an anomaly, as shown by the red square.



A particular cut was applied to the data to remove the values close to threshold.



A cut was applied to the seed ADC values to try to fix this problem. The cut was to make the seed ADC between ten and one thousand. This was to make sure that the ADC values were of a reasonable value. The lower cut was applied to see if this would make the distribution more homogenous.



The cut made the distribution much more homogeneous but did not address the problem completely. These low seed ADC values are the most likely the one hit clusters that have a total ADC close to the threshold.

Further work

The anomaly from the in-pixel position is not completely attributed to the one cluster hits that are close to the threshold. This algorithm will be looked into with new data from the upcoming test beams and with the new software package that has been written for test beam analysis. It will be expanded by looking at angle and voltage dependencies.

References

[1] The LHCb VELO group, “Radiation Damage in the LHCb Vertex Locator", *Journal of Instrumentation* 2013, 8.08
[2] Velthuis, J.J. , *Radiaition hardness of the ZEUS MVD fronted chip and Strangeness production in ep scattering at HER*A. PhD thesis